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RESEARCH ARTICLE

ASSESSMENT OF PHYSICOCHEMICAL ATTRIBUTES OF RIVER DAMODAR FROM BARAKAR ITS UPSTREAM ZONE TO BURDWAN THE DOWNSTREAM ZONE

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ABSTRACT

The river Damodar is subjected to a varying degree of pollution, caused by numerous outfalls of municipal and industrial effluents and by other activities. Clean water is essential to human survival as well as to the aquatic life. The study was conducted at twenty water quality monitoring stations in premonsoon, monsoon and postmonsoon seasons to assess the limnological characteristic of the river Damodar. Water pollution is one of the major problems in developing countries like India and the major river is subjected to various forms of pollution with regular decline in water quality. The life of aquatic organism depends directly on limnological characteristic of aquatic environment. The changes in limnological composition may leads to river water pollution. The seasonal data shows the range of a minimum concentration of most of the ionic particles in postmonsoon and a maximum concentration in premonsoon season, reflecting the concentrating effects. The major factors that decides the quality of the water in the study area is agricultural activities near the river downstream zone and also mining as well as industrial activities at the upstream zone of the river. The results of physicochemical parameters depict high mean values of alkalinity (304 mg/l), pH (8.3), sulphate (57.06 mg/l), phosphate (0.438 mg/l), nitrate (2.69 mg/l). High values of alkalinity, hardness, COD and chlorides indicate the pollution of reverine ecosystem due to domestic waste, municipal sewage, industrial effluents, organic matter and agricultural runoff.

INTRODUCTION

River is a dynamic system comprising both the main course and tributaries carrying the one way flow of a significant load of matter in dissolved and particulate phases from both natural and anthropogenic sources. The river basins are subjected to massive exploitation by both industrial and agricultural activities due to its extensive path way over very densely populated areas. The expansion of reverine microenvironment in relation to its socio-economic growth is continuously modifying the physical, chemical and biological composition of the river water. River pollution has become a major environmental problem that is becoming critical in developing countries of the world because of inadequacy of surface water quality protection measures and proper management. Several industries namely, chemical, paper, electrical and light engineering, consumer goods and other ancillary industries have led to a continuous influx of settlement on the river banks with a consequence to the deterioration and damage of the water quality of the river day by day. Agriculture is the backbone of the lower Damodar basin may also have some negative impact in pollutional view point. The living resources of the river have been degraded recently due to the increase in population pressure, pollution and natural resource consumption to the extent of overexploitation. Environmental and social policies associated with waste management are mostly inadequate and insufficient, resulting in increasing deterioration of the surface water environment. The present study critically assesses the limnological characteristics of the river Damodar at twenty e ecologically distinct zones under study. The surface water pollution is increasingly becoming a source of conflict among upstream and downstream water users because of the downstream user suffer the effects of upstream pollution. The quantity of water available for specific uses will decline with huge pollution. When the quality deteriorates, water loses its economic values. Various sources like industrial discharges, surface run-off, burning of fossil fuels, animal and human waste, geologic weathering and domestic waste contribute to the metal levels in water bodies (Wang and Zhuo, 2005; Awofolu et al., 2005; Adeniyi and Okedeyi, 2004; Arienzo et al., 2001; Edwards et al., 2001; Davis et al., 2001; Soltan and Rashed, 2001). Quality and quantity of river waters worldwide are under pressures due to high population density, inefficient use of fertilizers, biocides and irrigation for agriculture, discharge of untreated industrial and residential wastes, alteration of river courses, drainage water of mining activities, deforestation, atmospheric deposition, climate change, and land use changes (Giljanovic, 2003; Kambole, 2003). A huge quantity of river water during summer months, at dry season is withdrawn from its upstream and down stream reaches for agriculture, drinking and domestic purposes. During the monsoon period, in addition to normal discharge, flow of catchment water is increasing day by day due to unchecked deforestation and this causes regular

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flooding of the Damodar river during monsoon time. Aquatic ecosystem contamination is confirmed by determining levels of contaminants in water, sediment and organisms(Usero and Graccia, 2005; Altindag and Yigit, 2005; Yilmaz, 2003). The limnology plays a significant role in decision making process for problems like pollution control, fish and aquaculture practices. Several climatic factors such as rainfall, temperature, pressure and humidity etc. play a significant role in geology and terrestrial environment. The information regarding these factors helps in understanding the complex process of interaction between the climatic and biological process in water bodies. It is alarming that most of the cities and industries in river bank area are without waste water treatment facilities. Due to high organic loads in toxic materials the industrial effluents pollutes the river water.

Water-quality monitoring river Damodar is a helpful tool not only to evaluate the impacts of pollution sources but also to ensure an efficient management of water resources and the protection of aquatic life. Dissolved oxygen is one of the most important parameters of the water quality, directly effecting survival and distributing both flora and fauna in an ecosystem. The quantity of the dissolved oxygen (DO) in natural water is directly or indirectly dependent on water temperature (Agunwamba et al., 2006), partial pressure of oxygen in the air amount of chlorophyll content, etc (Welch, 1952; Wetzel, 1975).

Damodar River basin

Damodar is a small rain-fed river having a length of about 541-km, originating from the Khamerpet hill and flows through a vast track of the eastern India with variable topography and geology. The River basin area extends from 22^{0}45"N to 24^{0}30"N and 84^{0}45"E to 88^{0}00"E and circumscribes parts of the West Bengal and Jharkhand state. Damodar basin geology is mainly characterised by rocks consisting of granites and granitic gneisses of Archean age, sandstones and shales of the Gondwana age and the recent alluvials. The upland catchment area in Jharkhand comprises highly dissected peneplained upland with deep ravines and bare hills and the lower catchment area is within delta plains of West Bengal. The upland part of the basin is occupied by the rocks of Archean crystalline complex and basic intrusives. Lower part of the Damodar basin rocks of Tertiary age are covered by a thick veneer of alluvium. A large number of various industries, like coal washeries, steel plants, fertilizer manufacturers, thermal power plants, chemical factories etc. are located in the Damodar basin.

MATERIALS AND METHODS

The water samples were collected for limnological parameters from twenty water quality monitoring stations in the stretch of river Damodar from Barakar to Burdwan town. Industries in diverse fields such as steel plant, fertilizer, sponge iron, thermal power plant etc are located nearby side of this river. Samples were collected from the main flowing segment of the river, below the water surface. Water samples were collected in pre rinsed clean one liter polythene bottles. Analysis of samples were conducted for the parameter like pH, conductivity, water temperature, sodium, potassium, sulphate, phosphate, dissolved oxygen, biological oxygen demand by standard methodology (APHA, 1998). Temperature was measured using a mercury thermometer, immediately after samples from different places with a view to study the collecting the sample. Electrical conductivity (SYSTRONIC-306), pH and water temperature (thermometer) of the sampling sites were measured in the field. In each station, samples were collected in triplicate and prior to analysis in the laboratory, they were stored at a temperature below 4^{0}C.

RESULTS AND DISCUSSION

Sensitivity of many organisms to toxic waste is also influenced by water temperature and temperature change also. Water temperature ranges from 18 ^{0}C to 33.6 ^{0}C among all the sampling stations. The mean value of river water temperature was maximum (29.83 ^{0}C) in sampling site S4. Here water temperature varies in a range from 25.5 ^{0}C to 33.5 ^{0}C. pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions. In the biological system most of the biological processes and biochemical reactions are pH dependent. pH in the river water ranges from 7 to 8.91 among all the sampling stations. The mean highest pH value of the river Damodar was 8.50 in sampling site S14 which ranged from 8.3 to 8.91. pH is considered as an indicator of overall productivity that causes habitat diversity. The variation can be due to the exposure of river water to atmosphere, biological activities and temperature changes (Adebowale, 2008). Sewage and industrial effluent can also affect the pH balance in river.

The mean, range and standard deviation values of electrical conductivity in Damodar river water at different study locations are given in table 1.1 and 1.2. In natural water high electrical conductivity (EC) indicates a larger quantity of dissolved mineral salts (Trivedy and Goyal, 1986) and making it unsuitable for drinking (Gupta et al., 2003; Srivastava R.K. and Sinha, 1996). Electrical conductivity in the river water ranges from 100 µS/cm to 690 µS/cm among all the sampling stations. The mean value of electrical conductance of river water was maximum (493.33 µS/cm) in sampling site S14 where it varies in a range from 390 µS/cm to 550 µS/cm. Alkalinity is the quantitative capacity of water sample to neutralize a strong acid. Alkalinity in the study area ranged from 56 mg/l to 280 mg/l. The high mean value of alkalinity was observed in the site S9 (201.33 mg/l). The alkalinity values provide guidance in applying proper doses of chemicals in water and waste water processes, particularly in coagulations, softening and operational control of anaerobic digestion. Hardness in natural water is due to the presence of divalent metallic cations like calcium, magnesium, strontium, ferrous iron and manganese ions. Although hard water has no known effects on health but is unsuitable for domestic uses. In case of industrial activities it also forms heat-insulating scales in the boilers reducing their efficiency. The water of this river is unsuitable for industrial uses for such type of purpose. Hardness in the river water ranges from 64 mg/l to 428 mg/l among all the sampling stations. The mean value of hardness of river water was maximum (282.66 mg/l) in sampling site S5 where it varies in a range from 132 mg/l to 428 mg/l. Ammonia is toxic to aquatic life and toxicity is affected by water temperature and pH. The concentration of ammonia in the form of ammoniacal nitrogen in the river Damodar ranged from 0.009 mg/l to 4.42 mg/l in all the sampling sites. The

Table: 1.1 Chemical compositions of various constituents in Damodar river water samples

Sites		Wt	pH	EC	Alkalinity	Hardness	Ammonia	Nitrate	Sulphate	Phosphate	Sodium	Potassium
S1	Mean	27.433	8.123	193.333	94	98	1.874	1.8	23.377	0.25	19.167	7.867
	Range	21-33.3	7.87-8.3	100-310	74-106	88-104	0.42-4.426	1.29-2.71	19.25-27.17	0.114-0.483	13-24	5.5-9.1
	SD	6.17	0.225	106.927	17.436	10.67	2.217	0.79	3.971	0.203	5.62	2.05
S2	Mean	27.767	7.883	163.333	82	92	0.215	0.2	9.47	0.053	10.6	4.233
	Range	22-33.3	7.85-7.9	100-230	80-88	76-102	0.167-.287	0.16-0.26	7.58-12.02	0.003-0.091	4-19.8	3-5.1
	SD	5.654	0.029	65.064	4	17.286	0.063	0.053	2.292	0.045	8.215	1.097
S3	Mean	28.7	7.907	333.333	110.667	110.667	0.088	0.49	37.49	0.106	7.733	3.033
	Range	24-33.6	7.5-8.4	170-490	60-188	96-124	0.038-0.148	0.32-0.66	14.69-60.41	0.008-0.184	7.5-8.2	2-4.1
	SD	4.803	0.456	160.104	68.039	14.048	0.056	0.17	22.86	0.089	0.404	1.05
S4	Mean	29.833	8.033	270	170.667	113.333	0.516	0.573	46.42	0.154	15	4.333
	Range	25.5-33.5	7.7-8.5	170-360	112-204	100-124	0.282-0.86	0.34-0.78	24.34-62.8	0.106-0.21	9-25.5	3.5-5.5
	SD	4.041	0.416	95.394	50.964	12.22	0.304	0.221	19.853	0.056	9.124	1.041
S5	Mean	27	7.933	283.333	117.333	282.667	0.21	1.893	27.353	0.194	29	21.5
	Range	24-29	7.1-8.9	220-380	112-124	132-428	0.17-0.249	0.08-5.28	12.5-45.52	0.068-0.29	13-42	8.9-28.5
	SD	2.646	0.907	85.049	6.11	148.072	0.038	2.935	16.757	0.115	14.731	10.934
S6	Mean	27.533	8.067	425.333	105.333	261.333	0.218	1.61	24.773	0.244	19.667	11.7
	Range	26-28.6	7.8-8.4	300-650	100-108	128-380	0.15-0.268	0.77-2.51	18.98-32.01	0.067-0.34	11.5-25	9.9-14.2
	SD	1.361	0.306	288.444	4.619	126.639	0.059	0.872	6.634	0.154	7.182	2.234
S7	Mean	27.4	7.533	186.667	66.667	76	0.455	0.447	16.9	0.033	11.3	2.5
	Range	25.3-28.6	7-8.2	80-390	56-80	64-92	0.235-0.862	0.25-0.78	12.21-21.13	0.02-0.05	7-18.9	2.1-3.2
	SD	1.825	0.611	176.163	12.22	14.422	0.353	0.29	4.478	0.015	6.601	0.608
S8	Mean	27.233	7.34	196.667	82.667	96	0.28	0.413	21.197	0.085	10.633	4.367
	Range	24-29.5	7-7.72	190-210	64-92	88-112	0.17-0.411	0.18-0.78	15.42-29.39	0.039-0.11	5.5-17.5	3.5-5.1
	SD	2.875	0.362	11.547	16.166	13.856	0.121	0.321	7.292	0.04	6.185	0.808
S9	Mean	25.967	8.2	433.333	201.333	253	0.728	2.69	50.83	0.57	29.17	5
	Range	21-28.5	8-8.4	300-700	88-280	96-416	0.22-0.99	0.37-4.41	15.7-76.69	0.05-1.086	8.0-55	2.4-6.4
	SD	4.302	0.2	222.785	100.585	160.067	0.432	2.086	31.534	0.518	23.844	2.254
S10	Mean	25.9	7.967	366.667	101.333	126.667	0.135	0.733	29.8	0.066	16.703	5.833
	Range	21-28.6	7.8-8.2	210-570	88-120	92-152	0.053-0.25	0.48-0.89	19.75-44.24	0.01-.099	10.1-20.5	4.6-6.5
	SD	4.251	0.208	184.481	16.653	31.07	0.1	0.221	12.822	0.049	5.731	1.069

Unit: All parameters except pH and EC (μS/cm) and WT (water temperature, ^{0}C) are expressed in milligrams per liter

Table 1.2 Chemical compositions of various constituents (mg/l) in Damodar river water samples

Sites		WT	pH	EC	Alkalinity	Hardness	Ammonia	Nitrate	Sulphate	Phosphate	Sodium	Potassium
S11	Mean	29.167	7.673	240	74.667	96	0.085	0.96	22.197	0.03	10.67	4.067
	Range	19-33	7.1-8.32	150-320	56-88	72-124	0.01-0.145	0.32-1.71	12.8-28.48	0.007-.07	5.61-18.5	3.2-5
	SD	10.004	0.613	85.44	16.653	26.23	0.069	0.701	8.291	0.035	6.877	0.902
S12	Mean	25.1	7.907	263.33	80	86.667	0.066	0.507	17.49	0.208	10.117	3.367
	Range	19-29.3	7-8.6	190-33	60-108	68-96	0.019-0.123	0.22-0.72	11.8-23.13	0.08-0.44	4.65-19.5	2.1-4.8
	SD	5.406	0.821	70.238	24.98	16.166	0.053	0.258	5.665	0.205	8.163	1.358
S13	Mean	26.067	7.667	180	91.333	74.667	0.135	0.297	12.66	0.033	13.94	2.4
	Range	20.5-29.6	7-8.4	100-290	76-110	64-84	0.098-0.204	0.12-.45	10.36-16.32	0.01-0.05	8.42-22.9	2.1-2.6
	SD	4.879	0.702	98.489	17.243	10.066	0.06	0.166	3.204	0.022	7.829	0.265
S14	Mean	27.2	8.503	493.333	144	180	0.22	1.33	57.067	0.438	27.313	8.367
	Range	21-32	8.3-8.91	390-550	116-188	92-300	0.124-0.302	0.36-2.92	22.7-82.15	0.09-0.894	12.6-41.84	6-12.5
	SD	5.632	0.352	89.629	38.575	107.629	0.09	1.388	30.793	0.413	14.62	3.592
S15	Mean	27.833	8.35	490	132	214.667	0.26	2.43	56.943	0.205	28.92	8.533
	Range	21-33	8.3-8.45	260-690	92-160	152-308	0.167-0.411	1.02-4.89	24.16-90.15	0.08-0.324	10.46-49	5.4-12.7
	SD	6.171	0.087	216.564	35.553	82.397	0.132	2.138	32.997	0.122	19.321	3.758
S16	Mean	25.867	7.933	296.667	145.333	188	0.212	0.763	23.143	0.136	17.32	6.5
	Range	19-30.1	7.6-8.6	210-410	104-200	88-280	0.145-0.335	0.09-1.86	9.5-31.51	0.09-0.163	5.06-24.4	5.5-7.1
	SD	6	0.577	102.632	49.369	96.25	0.106	0.958	11.916	0.04	10.66	0.872
S17	Mean	25.367	7.65	253.333	108	105.333	0.133	1.347	16.723	0.302	11.203	2.9
	Range	19-29	7.2-8.05	150-370	96-116	76-128	0.019-.278	0.54-2.49	10.05-21.81	0.01-0.806	5.1-20	1.9-4.3
	SD	5.532	0.427	110.604	10.583	26.633	0.132	1.018	6.038	0.439	7.807	1.249
S18	Mean	25.867	7.7	266.667	101.333	126.667	0.051	0.59	26.613	0.079	11.27	3.033
	Range	18-31.5	7.6-7.8	210-350	92-116	88-188	0.009-0.081	0.31-0.99	13.58-43.42	0.006-0.18	4.8-16.9	2.1-4.6
	SD	7.022	0.1	73.711	12.858	53.715	0.037	0.356	15.274	0.091	6.094	1.365
S19	Mean	25.667	7.827	243.333	92	96	0.103	0.753	21.42	0.017	5.693	3.567
	Range	18-29.5	7.6-8	180-330	72-104	88-108	0.072-0.145	0.62-0.9	11.5-31.56	0.003-0.03	4.28-8.2	2.2-4.4
	SD	6.64	0.205	77.675	17.436	10.583	0.038	0.14	10.032	0.018	2.177	1.193
S20	Mean	24.7	7.667	240	84	98	0.019	0.653	25.31	0.037	10.78	3.133
	Range	18.5-29	7-8.1	180-330	80-88	76-112	0.014-0.024	0.53-0.87	12.39-38.29	0.017-0.054	5.34-14.5	1.5-5
	SD	5.502	0.586	79.373	4.0	19.287	0.005	0.188	12.95	0.019	4.816	1.762

Unit: All parameters except pH and EC (µS/cm) and WT (water temperature, ^{0}C) are expressed in milligrams per liter

Table 1.3: Chemical compositions of various constituents in Damodar river water samples

Sites		Iron	DO	BOD	Sites		Fe	DO	BOD
S1	Mean	0.578	5.224	2.048	11	Mean	0.362	7.461	1.768
	Range	0.313-1.03	1.61-7.21	0.76-3.973		Range	0.078-0.66	5.68-8.6	1.216-2.43
	SD	0.395	3.135	1.698		SD	0.293	1.566	0.616
S2	Mean	0.895	7.802	3.487	12	Mean	0.364	5.512	1.876
	Range	0.77-1.066	6.85-8.91	1.975-4.85		Range	0.039-0.73	3.65-8.83	0.764-3.243
	SD	0.153	1.041	1.446		SD	0.348	2.884	1.259
S3	Mean	0.497	6.739	1.74	13	Mean	0.108	7.74	2.029
	Range	0.48-0.513	5.68-8.1	1.57-2.019		Range	0.085-0.15	7.12-8.9	1.62-2.481
	SD	0.017	1.239	0.243		SD	0.038	1.005	0.432
S4	Mean	0.692	4.981	0.872	14	Mean	1.254	6.2	3.124
	Range	0.603-0.85	4.03-6.89	0.378-1.65		Range	0.24-3.089	3.65-7.75	2.48-3.648
	SD	0.14	1.653	0.687		SD	1.593	2.227	0.593
S5	Mean	1.935	5.394	2.004	15	Mean	0.61	5.197	4.23
	Range	1.01-3.73	3.65-7.29	0.452-3.24		Range	0.30-1.145	3.61-7.12	2.847-4.98
	SD	1.563	1.829	1.422		SD	0.465	1.78	1.199
S6	Mean	1.693	6.067	1.849	16	Mean	0.265	7.13	1.907
	Range	0.36-3.71	4.03-8.93	0.38-2.85		Range	0.229-0.31	6.08-8.01	0.452-4.054
	SD	1.781	2.56	1.302		SD	0.042	0.976	1.898
S7	Mean	0.244	6.852	2.061	17	Mean	0.157	6.823	2.417
	Range	0.15-0.355	5.23-8.83	1.96-2.229		Range	0.106-0.23	4.4-8.107	1.982-3.24
	SD	0.103	1.827	0.146		SD	0.065	2.05	0.715
S8	Mean	0.231	6.189	3.243	18	Mean	0.186	7.304	1.903
	Range	0.156-0.32	6.04-6.48	1.622-4.45		Range	0.067-0.33	6.49-801	1.216-2.43
	SD	0.089	0.257	1.462		SD	0.136	0.822	0.623
S9	Mean	0.349	5.642	2.836	19	Mean	0.292	7.363	1.769
	Range	0.19-0.603	2.84-8.41	1.986-3.68		Range	0.195-0.47	6.08-8.10	1.217-2.06
	SD	0.222	2.787	0.852		SD	0.158	1.115	0.478
S10	Mean	0.472	6.668	2.31	20	Mean	0.219	5.893	3.513
	Range	0.095-0.92	6.08-7.2	1.621-3.68		Range	0.056-0.48	5.27-6.89	2.432-5.27
	SD	0.421	0.565	1.194		SD	0.229	0.874	1.535

Unit: All parameters are expressed in milligrams per liter

aximum mean value of ammonia nitrogen (1.87 mg/l) at sampling station (S1). The mean, range and standard deviation values of ammonia in Damodar river water at different study locations are given in table 1.1 and 1.2. Nitrate nitrogen is one of the most important indicators of pollution of water. Nitrate, the most highly oxidized form of nitrogen compounds is commonly present in surface and groundwaters because it is the end product of the aerobic decomposition of organic nitrogenous matter. The mean, range and standard deviation values of nitrate in Damodar river water at different study locations are given in table 1.1 and 1.2. The concentration of nitrate varies between 0.08 mg/l to 5.28 mg/l in the study period. The mean concentration of nitrate of sampling station S9 in the Damodar river ranged from 0.37 to 4.41 mg/l with a maximum Value 2.69 mg/l. When nitrogenous fertilizers are applied to soils, they are rapidly converted in arable soils to NO_3 form, which are readily available to the plants, but are highly soluble and hence easily leachable. The maximum mean sulphate concentration (57.06 mg/l) of river water sample in the study area was observed in sampling site (S14). The sewage effluent containing sulphate may produce hydrogen sulphide that in the form of sulphur which is poisonous so the untreated sewage should be treated before letting into the receiving water bodies. Acid mine drainage is the source of sulfate ions to water environment. A number of crops show sensitivity to very high concentrations of sulfates in irrigation water. Phosphorous occurs in natural water almost solely as phosphates and the concentration of the water sample was ranged from 0.003 mg/l to 1.086 mg/l among all the sites comprising highest average value of 0.57 mg/l in sampling station S9. The excessive phosphate concentrations evoke an algal bloom in the water. Elevated concentration of inorganic phosphate to the lakes, rivers, bays and other surface water causes excess nutrition, resulting in excess growth of phototrophs and depletion of dissolved oxygen. Phosphorus is the limiting nutrient for plant growth in freshwater systems and plays a key role in process of eutrophication. A comprehensive river water quality monitoring is becoming a necessity in order to safeguard the public health and to protect the valuable river water resources. The mean, range and standard deviation values of iron in Damodar river water at different study locations are given in table 1.3. Iron is an essential element for plants and is required in enzymatic processes such as chlorophyll and protein biosynthesis. Iron concentration in the river water ranges from 0.039 mg/l to 3.73 mg/l among all the sampling stations. The concentration of mean iron in the river Damodar was maximum (1.935 mg/l) at sampling site S5.

Dissolved oxygen in the river water ranges from 1.61 mg/l to 8.93 mg/l among all the sampling stations. Amount of dissolved oxygen is a significant characteristic of aquatic system, enabling organisms to perform respiration and revealing the rate of primary production, which is the basis of the trophic structure. Dissolved oxygen is the factor which determines whether the biological changes are brought about by aerobic or anaerobic organism. It reflects the physical and biological processes prevailing in the water. The oxygen present in water can be dissolved from air or produced by photosynthetic organisms. These values indicate relatively mild organic pollution. BOD values indicate the extent of organic pollution in the aquatic systems, which adversely affect the water quality. BOD in Damodar river water ranges from 0.378 mg/l to 5.27 mg/l. Types of micro-organism, pH, and presence of toxins, some reduced mineral matter and nitrification process are the important factors influencing the B.O.D. in water. The aim of B.O.D. test is determine the amount of bio-chemically oxidisable carbonaceous matter (Edwards et al., 2001; Giljanovic, 2003). Physico-chemical attribute like D.O. also indicates presence of organic pollution which can be attributed to the non-point sources scattered over the entire study zone.

Conclusion

Study reveals that the main sources of organic pollution are non-point sources like domestic sewage and agricultural run-off. The river facing increased concentration of BOD, nitrate, phosphate in some areas with intensified use of chemical fertilizers together with increased urbanization. The measured parameters determining the current pollution level of the river Damodar can be used in planning an appropriate remediation program to improve the water quality of the river. The quality assessment of river water shows that in general, the water is suitable for various usages though continuous discharge of effluents at some industrial effluent discharge point putting the integrity of rivers at risk. Based on the results it is cleared that the water quality assessment and periodical monitoring is needed for the Damodar river.

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